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Endoscopy is an essential method for the diagnosis and treatment of diseases in the esophagus, stomach, duodenum and colon in human and veterinary medicine. However until only a few years ago, most of the small bowel was an under-investigated frontier not accessible using conventional endoscopic techniques. For the first time in Japan, in 2001, Yamamoto et al. introduced the double-balloon enteroscopy (DBE) system that enabled endoscopic inspection of the entire small bowel[1]. DBE consists of an enteroscope and a soft overtube. A balloon is attached to the tip of the endoscope and another to the tip of the overtube. Each balloon can be inflated and deflated by a pressure-controlled air pump system. Preliminary tests in Japan and Germany showed that this system can be used to perform total small intestine enteroscopy with a good safety profile and patient tolerance. DBE has become established throughout the world for diagnostic and therapeutic small bowel examinations, and is now being used widely in routine clinical work[2]. In 2007, another balloon enteroscopy system has been introduced, that is equipped with only one balloon at the tip of the overtube and is therefore known as single balloon enteroscopy (SBE)[3].

Double balloon enteroscopy (DBE)

The DBE system (Fujinon, Inc. Saitama,Japan) consists of a high-resolution video endoscope, with a working length of 200 cm and a flexible overtube made of polyurethane. A latex balloon is attached at the tip of the enteroscope and also on the overtube, and can be filled with air or emptied using a pressure-controlled pump. The principle of the DBE technique is based on alternating pushing and pulling maneuvers, allowing the small bowel to be threaded step by step onto the overtube (5,6 aus May). Two different devices are currently available with the double-balloon system: the EN450-P5 model, with a working channel of 2.2 mm and an outer diameter of 8.5 mm, and the EN450-T5 model, with a working channel of 2.8 mm and an outer diameter of 9.4 mm. The corresponding overtubes have diameters of 12.2 and 13.2 mm respectively, with an overall length of 145 cm.

DEB technique

During the insertion process, the endoscope is first inserted until it reaches the stomach, and the overtube is then advanced over the endoscope. The endoscope is then inserted further, through the pylorus, and its balloon is inflated to maintain a stable position within the intestinal

lumen. The overtube is then advanced along the endoscope and its balloon is inflated. When both balloons are inflated, the tips of the endoscope and the overtube are pulled slowly together, to gather and shorten the intestine between them on the overtube. This simplifies the shape of the intestine ahead and avoids the formation of redundant loops (Fig 1). The balloon of the endoscope is then deflated, and the endoscope is advanced while the system is fixed by the balloon on the tip of the overtube. When the endoscope is stable again, with its balloon inflated, the balloon of the overtube is then deflated and advanced to reach the tip of the endoscope. These procedures are repeated, moving the system further and further into the small intestine. In this way, the working length of the endoscope can be used most effectively, and the endoscope can be advanced distally after the intestine has been shortened and its shape simplified.

To the author's knowledge, DBE in dogs has only been described by Latorre et al., in 2007 in the veterinary literature[4]. Two laboratory dogs weighing 23 kg and 26 kg were used and the technique (EN-450P5) was applied using both oral and anal approaches.

The total time for the antegrade examination was 2 h and 10 min and the estimated depth to which the endoscope was inserted was 4.95 m. The first meter was reached in the first 15 min by advancing four times. The 2nd meter was reached within the next 20 min by advancing five more times, and the 3rd meter was reached after another 15 min and five more maneuvers. In total, 26 advancing movements were performed. At the beginning each advance was often up to 30 cm, however after proceeding more distally, 10 cm advances became more common. No complications were noted during the procedure. The balloons used in this study were inflated to 45 mmHg (6 kPa), which is the lowest pressure needed to hold the human intestine for endoscope insertion and is designed not to cause pain or discomfort. There are no references about the pressure required for use in pet dogs, but results obtained with four anatomical specimens (gastrointestinal tracts from post-mortem examinations) showed that 45 mmHg was satisfactory[4].

Fluoroscopy was used to evaluate the performance of DEB in the dogs mentioned in the study. Results from a recent study in people, however, showed that radiographic control of the enteroscope's position does not help to determine its depth of insertion, because even in the best circumstances, the repeated push-and-pull procedures create similar radiographic images[5].

Single ballon enteroscopy (SBE)

The SBE system was recently introduced (Olympus, Inc. Tokyo, Japan). The enteroscope (SIF Q 180) is a high-resolution video endoscope, with a working length of 200 cm. The enteroscope is equipped with a working channel that is 2.8 mm in diameter, with an outer diameter of 9.2 mm. The disposable overtube has an overall length of 140 cm, consists of

silicone, and has a latex-free balloon made of silicone at the distal end. The outer diameter is 13.2 mm. In contrast to the DBE system, no balloon is attached to the tip of the enteroscope, and stable positioning in the small bowel is achieved during the withdrawal of the scope, by angling the tip of the endoscope. The SBE is extremely flexible with its distal angulation reaching 180° up and down, and 160° right and left.
Insufflation of the overtube balloon is performed using a pressure-controlled pump with pressure ranging from 6-16 kPA. Balloon pressure is regulated at approximately 5.6 kPa (42 mm Hg) by a pressure-sensing feedback mechanism. An alarm is activated when the balloon pressure is greater than 8.2 kPa for 5 seconds or longer.
Interestingly, results of experiments to determine the necessary inflation pressure for latex balloons that would be associated with satisfactory grip of the small intestine were performed in dogs. Inflation pressures between 45 and 100 mmHg (5.9 - 13.3 kPa) produced suitable and safe pressures[6]. However, the author has not yet exceeded pressures above 7 kPa.

SBE technique

Although silicone rubber is used in the overtube (ST-SB1-Disposable Sliding Tube), a hydrophilic lubrication coating inside of the tube lining ensures better lubrication between the scope and overtube. Because of this, only water is needed to ease friction between the back loaded overtube and scope. The official recommendation is for single-use only, but the author has successfully re-used this rather costly sliding tube multiple times without any problems. Prior to passage of the scope it is prudent to confirm that the balloon is functioning properly.
First, the scope is passed into the stomach, then the overtube is passed over the scope into the stomach. At this point, it is crucial not to insufflate too much air into the stomach, as this will lead to antegrade duodenal air trapping with resultant slippage of the inflated ballon back into the antrum. A minimum safety distance of approximately 15 cm should always be kept between the distal end of the overtube and the enteroscope (60 cm mark) in order to prevent damage of the scope when angulating its distal end. Next, both the scope and the overtube are advanced as far into the small intestine as possible. The flexible nature of the enteroscope can create difficulty with pyloric intubation initially because the enteroscope will tend to loop into the retroflexed position in the stomach. This issue however can improve quickly with operator experience. It is vital to make sure that the overtube has definitely passed the flexura duodeni cranialis before inflating the balloon for the first time, as an unnoticed sliding back of the inflated overtube into the pyloric antrum will result in numerous unsuccessful push-pull maneuvers. Ideally, the balloon is not inflated in the area of the proximal duodenum so as to avoid trauma to the papilla and lessen risks of pancreatitis.
Next, the balloon is inflated and the scope is reduced by gently pulling back on both the overtube and scope together (Fig 2). In the first few

cases that the author performed, fluoroscopy was helpful to visualize the enteroscope movement during reduction and check the hub of the balloon. Once the balloon enteroscope is completely reduced, the balloon is kept inflated, and the tip of the enteroscope is advanced as far as possible. Then, the balloon is deflated and the overtube is gently passed over the scope until the 60 cm mark is reached. Next, the balloon is re-inflated and reduction of the scope is repeated. This cycle is repeated to advance the scope as far as possible into the small intestine or until the lesion in question is encountered.
One of the most important points when proceeding quickly and especially distally is keeping air insufflation to a minimum. When there is a large amount of air that is allowed to enter during insertion of the endoscope and pulling back of the endoscope and the overtube, with a lesser amount of air that is sucked out between the individual steps of the push-and-pull maneuvers, there is a greater space that is created and therefore needed on the overtube for threading the small bowel. With this air trapping, the overtube quickly becomes "full" of small bowel; no more small bowel can be threaded onto the overtube, and the procedure has to be stopped, regardless of the insertion depth achieved up to that point.

Indications for DBE and SBE

Suspected or known mid-gastrointestinal bleeding represents the principal indication for both procedures in humans. Balloon enteroscopy also represents the procedure of choice for patients with suspected small-bowel tumors, because it allows for histologic sampling in contrast to video capsule endoscopy alone. Another indication of DBE and SBE in people is obstructive Crohn's disease, as it allows dilation to be performed.
Indications in veterinary medicine are most likely very similar and may include inflammatory enteropathies, ulcers and erosions, as well as intestinal bleeding secondary to angiodysplasia and neoplasia. However, the clinical use of balloon enteroscopy still needs to be evaluated in dogs with gastrointestinal disease.
A recent study comparing the histopathologic findings of duodenal and ileal biopsies in dogs with enteropathies suggested that routine collection of ileal biopsies is warranted if large intestinal signs are also present. The authors concluded that routinely sampling both small intestinal sites has implications for clinical practice[7]. Although not yet proven, this may also be the case in dogs with exclusive small intestinal disease. In that study by Casamian-Sorrosal, a higher percentage of adequate samples were obtained from the ileum than from the duodenum, and it is imaginable that biopsy quality could be improved with the use of ante- or retrograde balloon enteroscopy.

Complications

In humans, the complication rate of diagnostic DBE is low and expected in only 1 % of cases. The most severe complication is pancreatitis, with a risk of 0.3 % in oral DBE[8]. The only data available on mortality rate is from the German double balloon registry, where the mortality rate is 0.05% (death occurred after pancreatitis and a complicated postoperative course after perforation during polypectomy for a small bowel polyp). The SBE technique with only the overtube balloon for fixation, demands angulation of the tip of the endoscope while the endoscope is pulled back or the overtube advanced. In theory this "hooking" might lead to mucosal damage or extended stretching of the mesentery. However, results of a recent prospective Dutch study evaluating complications of 166 SBE procedures also suggested that SBE is a safe diagnostic endoscopic procedure[9].
The author has not encountered major complications (i.e. perforation) or clinical pancreatitis in his patients after SBE, although pancreatitis markers have not specifically been evaluated post procedure.

Limitations of balloon enteroscopy

The anatomy of the canine small intestine may limit the safety and effectiveness of balloon enteroscopy in veterinary medicine. Lopez Albors and colleagues recently measured the length and width of the small bowel in 55 dogs in a detailed morphometric study[10]. Based on their results the duodenum (2.37 ± 0.05 cm), is the least risky portion of the small intestine for balloon enteroscopic exploration, whereas restrictions to the progress of the enteroscope could be more likely in the jejunum (1.95 ± 0.03 cm) and ileum (2.1 ± 0.05 cm). The authors assumption however, that intestinal widths of < 2 cm might give excessive mechanical resistance to the progress of the endoscope, must be verified in clinical studies. The author has performed SBE in dogs ranging from 16.3 to 40.2I kg BW without complications, with the final insertion depth in the 16.3 kg dog (Beagle) estimated to be just under 3 meter.
Likewise, in human medicine, the first successful antegrade SBE in a three-year old child with occult intestinal bleeding weighing 13.5 kg was carried out without complications in 2009[11]. A complete inspection of the small bowel (i.e. down to the ileocolic valve) is rarely accomplished in people with SBE, and has not been achieved by the author yet.

Another limitation is the lengthy procedure time, which can be prohibitive in patients with a high anesthetic risk. The average procedure time in the author's hospital is approximately 2 hours and there does not seem to be a significant learning curve associated with SBE in terms of technical difficulty of the procedure. Experienced endoscopists require only 38 (12-90) minutes for antegrade balloon enteroscopyin humans, with the majority of cases performed without fluoroscopy[12].

Prospective clinical trials are needed to assess the utility (feasibility, diagnostic yield, complications) of balloon enteroscopy as well as the advantage of one system over the other in dogs. It is possible that more knowledge about canine small bowel disease can be generated with these new and exciting techniques.

References
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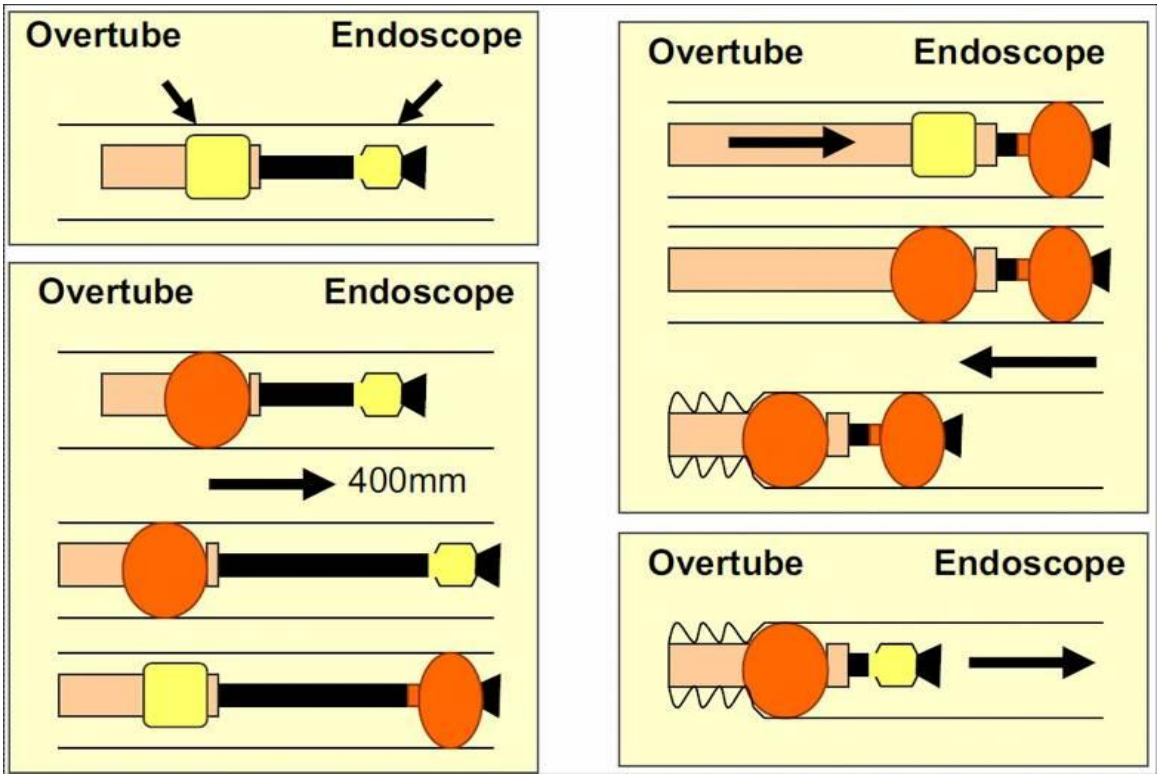

Fig 1: Insertion procedure with Double Balloon Enteroscopy (DBE)

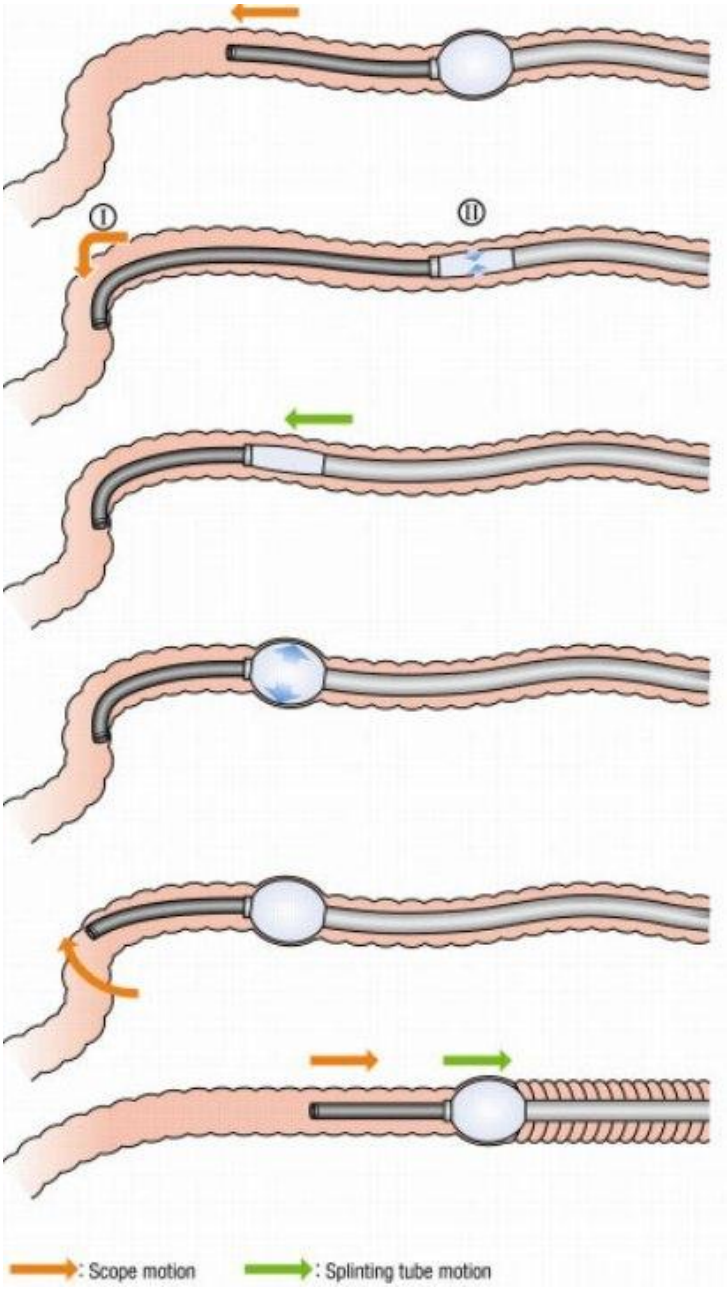

Fig 2: Insertion procedure with the Olympus Single Balloon Enteroscope system (SBE)